URBAN CALCULATOR

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INTRODUCTION

Major steps have in recent decades been taken when it comes to understanding how cities work. Essential is the change from understanding cities as locations to understanding them as flows (Batty 2013). In principle this means that we need to understand locations (or places) as defined by flows (or different forms of traffic), rather than locations only served by flows. This implies that we need to understand the built form and spatial structure of cities as a system, that by shaping flows creates a series of places with very specific relations to all other places in the city, which also give them very specific performative potentials. It also implies the rather fascinating notion that what happens in one place is dependent on its relation to all other places (Hillier 1996). Hence, to understand the individual place, we need a model of the city as a whole.

Extensive research in this direction has taken place in recent years, that has also spilled over to urban design practice, not least in Sweden, where the idea that to understand the part you need to understand the whole is starting to be established. With the Urban Calculator that we present here, we take a important leap towards integrating this knowledge in the daily practice of urban designers and other professionals active in urban development. The objective of this project is to provide a user-friendly software that allows for effective knowledge transfer. The software will support the evaluation of different urban scenario's as well as mirror these against a references database. The project is expected to impact decision making in urban development projects, especially during the initial phases.

The problem this project provides a solution for, is the lack of effective evaluation tools that consider both trade-offs and system effects. This, in turn, causes potential losses of quality of life and can increase economic costs. Furthermore, because the urban environment is not easy to change, these losses endure over long periods of time. With this software, the evaluation of design alternatives can become part of the decision making process early in the planning process when modification still are feasible.

An integral part of the proposed tool concerns data collection, availability, quality and uniformity. To ensure a scalable solution where all municipalities in Sweden and even outside Sweden can use the tool, the development allows to add other geographies and additional layers. However, the method to ensure these additional maps have the same quality as the one included now for Gothenburg as not been fully automated yet. With this implemented, the tool will make the design process more transparent and will potentially ensure a more equal and consistent evaluation process within and across municipalities, which is important for democratic processes. This is especially of importance for smaller municipalties with less resources.

The Fusion Point project, but also previous collaborations between the research group SMoG at Chalmers and various municipalities, not least Gothenburg, has provided insight that this understanding of built form and spatial structure as a system is needed very early in the planning process. One simply needs to understand how an intervention in one project has effects not only within the project, but also elsewhere in the city. But even before that, the understanding of the potentials of the project due their location in the city, is crucial knowledge to be able to propose changes. Different design interventions, such as the position of a new bridge over the river, should thus be tested as part of the design process and not as an analysis that comes at the end.

An iterative process of design and analysis will make information about positive and negative effects of the intervention important input for further investigations and alternative solutions. Thus, the proposed process includes analysis as integrated part of the design process as shown in Figure 1. In current practice, however, the analysis often follows the design process instead of being an integarted part of it, because the skills to make such analysis are not common amongst planners and architects. To solve this knowledge gap, external (or internal) experts are consulted, but this either slows down the design process or the feedback risks to be received too late in the process. To counter this problem, the Urban Calculator should therefore allow urban planners and designers to test ideas themselves and this should already start in the explorative, concept formulating phase of a project. This means that one of the main features of the tool is user-friendliness and ease of use. This also makes a clear divide between the role this tool can have in relation to the way similar spatial analysis in more advanced GIS tools are done today.

Professionals without GIS experts will, through the Urban Calculator, be able to conduct spatial analyses that because of the limits in its number of features and because of the strong knowledge tradition it builds on, results in correct and informative feedback. After the user has elaborated different design alternatives and

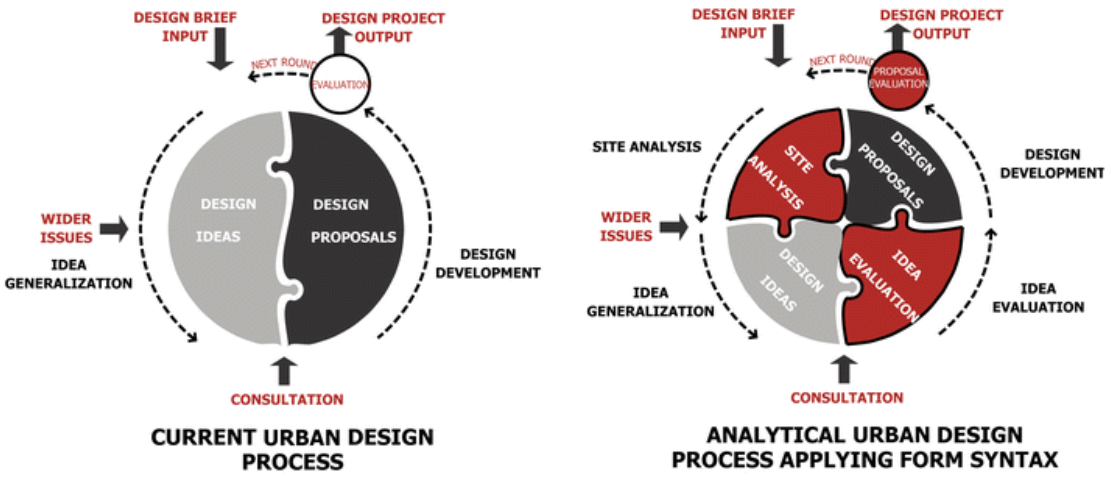

Figure 1. Design process using a more conventional design process (left) and an integrated analytical approach (right) versus (Ye et al. 2017)

arrives at a final proposal, more advanced analysis can and should be done using the conventional GIS spatial analysis tools. In other words, this new tool will not replace the old ones, but complement them targeting other user groups. This idea was confirmed during the test panel meetings where both designers, non-GIS users and GIS experts working with the conventional GIS methods participated (see appendix 3 for details).

The base for the Urban Calculator are the spatial analysis functionalities available in the software PST, developed by Chalmers in cooperation with KTH, Spacescape AB and XMN Software AB. PST (Place Syntax Tool) is an open source software for spatial analysis. It combines the space syntax description of the urban environment with conventional descriptions of attraction into a combined accessibility analysis tool. It is currently available as a plugin for the MapInfo Professional GIS software and for QGIS, an open source GIS software. Both the plugin tool PST and the documentation are available via Chalmers: www.smog.chalmers.se/pst.

FUNCTIONALITIES

The main functionalities of the Urban Calculator that are identified necessary to develop an informative tool for professionals in urban development without GIS expertise are (i) modifying the map to test design proposals, (ii) analysing the existing situation or plan proposal and (iii) consulting a reference database. It should be noted that not all of these functionalities were emphasised when the project started and the budget did not allow us to include them all. Especially, the third function group (reference areas) was not part of the project proposal from the start, but was later added with financial support from the Swedish Environmental Protection Agency (*Naturvårdsverket*). Before discussing the main function groups, the maps and data included in the application are presented below. For now, this is limited to Gothenburg including neighbouring municiapalities that together form a so called urban morphologial zone (UMZ, see appendix 2 for details), but this can be extended to other areas in Sweden and abroad as we discussed in the introduction.

Maps and data

The Urban Calculator uses base maps developed by the research group SMoG at Chalmers. Currently, only maps of Gothenburg are implemented, but the tool is scalable and other municiplities in Sweden and abroad can be included relatively easy. The different map layers currently included in the Urban Calculator are:

- Modifiable layers: motorised and non-motorised street network where the non-motorised model includes all streets and paths that are accessible for people walking or cycling, including those that are shared with vehicles. All streets where walking or cycling is forbidden, such as motorways, highways, or high-speed

tunnels, are not included, but are part of the motorised street network.

- Non-modifiable layers: buildings, plots, water bodies, schools (primary schools and kindergarten), local markets (i.e. restaraurants and shops), public transport stops, population.

Editing the map

It should be possible to make changes in the base maps to test different design alternatives. For streets, for instance, this means that one has to be able to add, move, change and remove lines. The tool is developed so that one does this in a manner that allows for network analysis, For instance, new lines are always linked to existing lines, so the tool "snaps" your new line always to an existing one. To make changes in the street network is prioritised above modification in other layers, because it is the base for all analyses. The other layers could also become modifiable layers in the future.

Analysing the map

The current situation, but also the modified map, can be analysed using similar analysis as currently included in PST. The difference with PST is that in the Urban Calculator most choices and settings are pre-defined and the choices the user has to make are reduced to a minimum, without however simplifying the analysis. The output gives, besides results on the map, a description in text of what the specific analyses mean, which will help the user to interpret the results and draw correct and informative conclusions. Here it should be noted, that some basic knowledge about the theory of space syntax is needed.

Three spatial analyses are included in the Urban Calculator: built density, street centrality and accessibility to services. These three groups of analysis are acknowledged to be key design strategies for sustainable urban development

(e.g. Cervero, 1997; Berghauser Pont et al. 2019) and often reoccurring in design guidelines such as the global Sustainable Design Strategies of UN Habitat (2015) and the Swedish Indicators for Quality (Spacescape, 2017). However, these guidelines and similar scoring and rating tools usually lack essential considerations of the relationship between indicators and scales (system effects), are time-consuming and therefore carried out in the last phase of detailed design (Lee et al. 2010). This is one of the reasons for an inefficient design process and can, in turn, cause a potential loss of quality of life and huge economic costs. More details about the analysis are included in the next chapter.

Relating to reference areas

The third part of the tool is to inform the user how the tested proposal or any existing street the user selects, relates to existing streets in Gothenburg. The database provides photographs of streets of similar kind as the one in selected, but also some key information of these areas (see Figure 2 on the next page). This will help the user to see in what sense other streets are similar to the newly proposed one, but also give insight in what way they are different. For instance, they can be similar in terms of desnity, but different in terms of centrality. This will make the use of references in the urban design process more accurate and thus more relevant.

Delimitations and potential extensions

Functionalities that are not included today, but were discussed with the test panel and highlighted as important, are the following. In relation to *editing*, the extension of modifiable layers was discussed such as adding or removing buildings and schools. In terms of *analysis*, we did not implement the analysis of the changes in performance before and after the intervention. Such an analysis would simplify the comparison between two maps by combining the results of both in one single map. The *reference*

database could be extended to include more streets in Gothenburg or elsewhere if the process of an automated gathering of street views (photographs) from e.g. google streetmap was implemented.

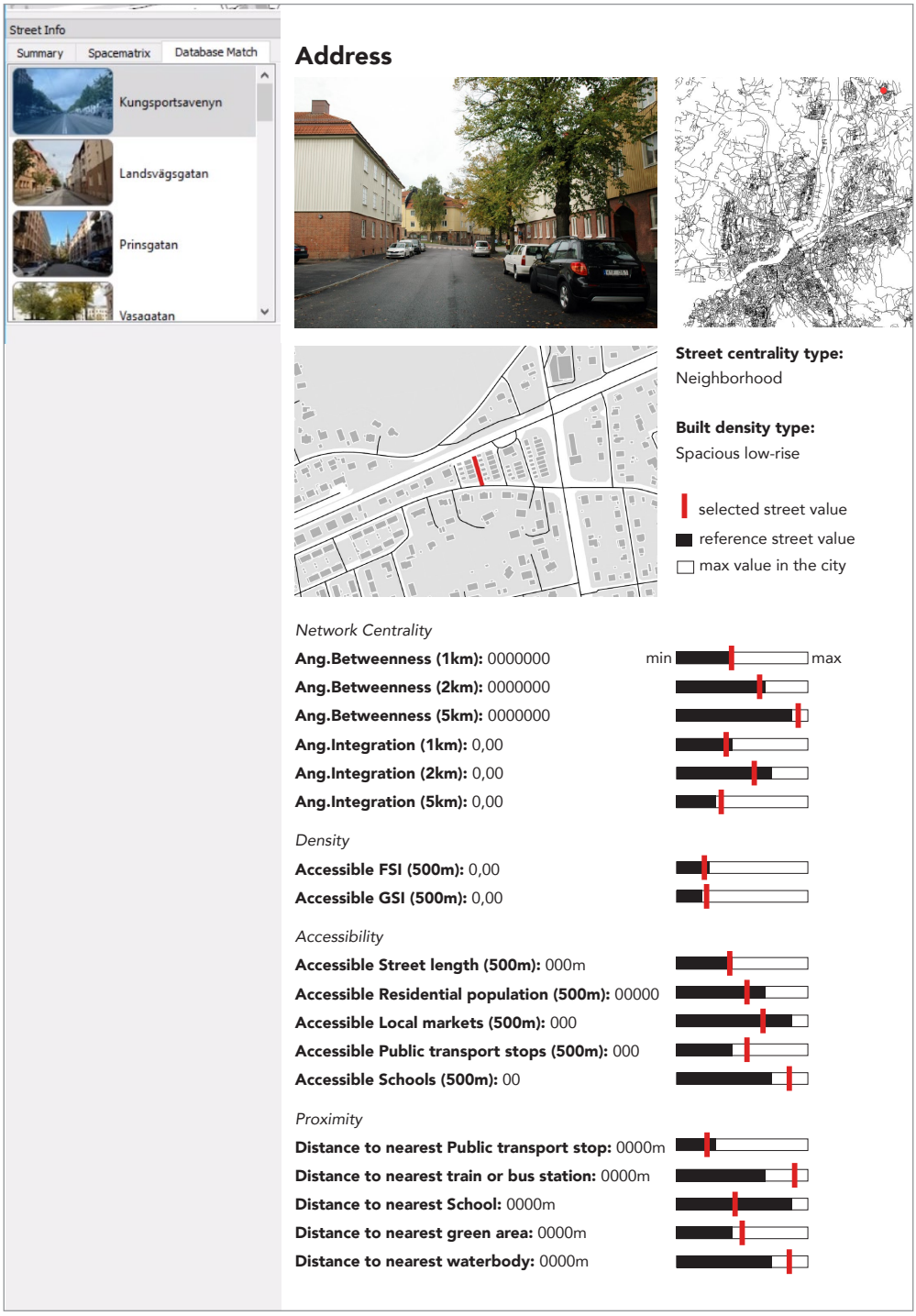

Figure 2. Output from the reference database

SPATIAL ANALYSIS

The spatial analyses that are included in the Urban Calculator are street centrality, accessibility to services and built density. In all three, network analysis is central. Networks describe how different components (of a system) together build a whole that in turn effect the parts. To describe a network, graph theory is used which describes the world with only two elements: nodes and links (or edges). Nodes usually describe the elements in a system (i.e. a station in a public transport system or a street in a street system), and the links describe how these nodes are connected to one another. Such descriptions are used in very different fields such as social sciences, biology and physics and are the base for space syntax theory.

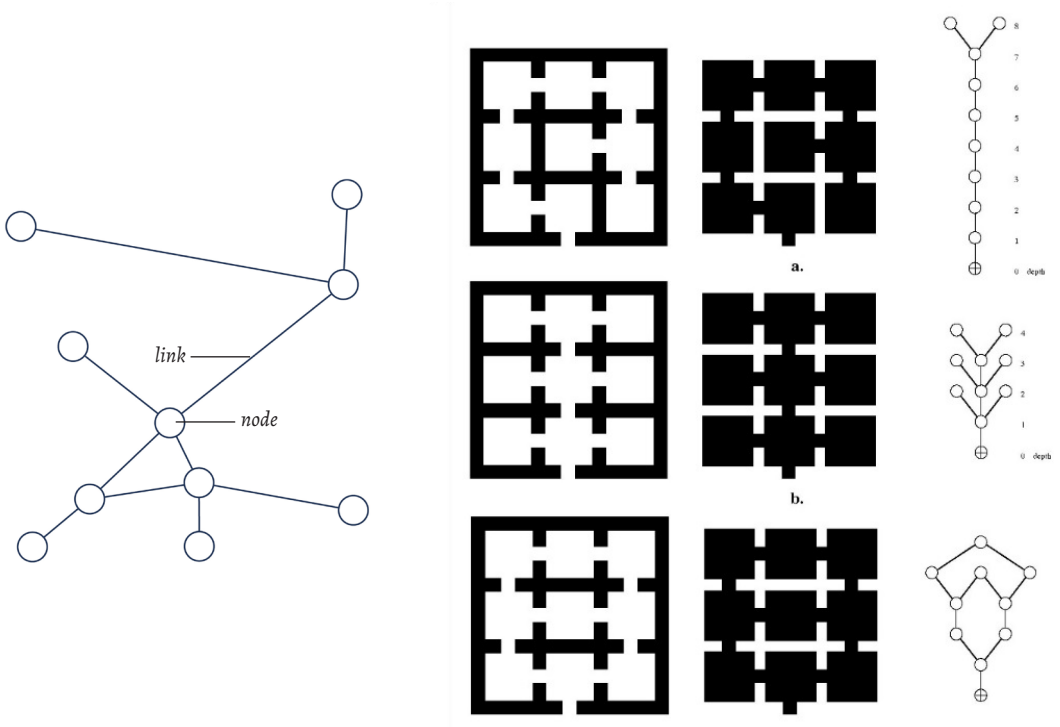

Figure 3. Network graph with nodes and links and how this can be used to describe urban form as system of connecting "rooms" . The tree examples on the right show how adding doors changes the graph and the centrality of the rooms (Hillier 2004)

Measuring Centrality

Centrality can be measured in several ways, but the most commonly used measures in Space Syntax are integration and choice or, using the more exact terms of network theory, angular closeness centrality (often referred to as *närhet* in Swedish) and angular betweenness centrality (often referred to as *genhet* in Swedish). Angular centrality measures calculate the distance between two contiguous street segments by way of measuring their angular deviation. In extension, the shortest path between two distant segments is the path with the least angular turns in total.

Angular betweenness centrality of a street segment is the number of shortest paths between all other segments in the network that pass through it. A street segment with high betweenness is one that falls most frequently on such shortest paths, as for example are the bridges, which control all movement between the city center and Hisingen. On the other end, the dead-end streets have zero betweenness centrality since no path passes through them. On a global scale the measure highlights the "through" movement structure in the city.

Angular closeness centrality calculates how "far" in terms of its total angular distance, is every street segment from all other segments in the network. A segment with high closeness centrality is one that is largely connected to other streets and is highly accessible in few angular turns, as for example the clusters of the well-connected streets in the city center. On the other end, a segment with low closeness centrality has only a few connections to other streets, it is deep in the structure and requires a lot of turns to reach it, making it less accessible and segregated. Such examples are the clusters of the inner meandering streets of the modernistic estates. In a global scale, the measure distinguishes between the integrated and segregated areas in the city. Both measures have been shown to correlate to traffic and pedestrian flows,

where high centrality in the motorised network is related to high vehicular traffic whereas high centrality in the non-motorised network is related to high pedestrian flows (e.g. Serra and Hillier, 2018; Stavroulaki et al. 2019; Hillier and Iida, 2005). They also correlate to the concentration other activities and attractions, such as the development of local markets (Marcus et al. 2017).

Accessibility to services

Besides the characteristics of the network in itself, streets also give access to people and services. Accessibility can be measured in two ways. First, attraction distance that captures proximity to services and calculates the distance from the point of ´origin´ such as addresses to some kind of attraction, for instance primary schools. The second measure, attraction reach on the other hand, calculates the total amount of attractions that can be reached within a certain distance from the points of origin. Thus, this is a kind of density measure giving you an idea of how many schools, shops or people can be reached within a neighborhood (defined by distance). Attraction analysis can also be seen as a description of the presence (or absence) of society and answers questions such as: *"Which services are available in walking distance?", or "How equal is service distributed in Gothenburg?"* The analyses captures more precisely what resources are ´around the corner´, things that are easily accessible and do not require a large time or monetary investments (due to the transport mode chosen).

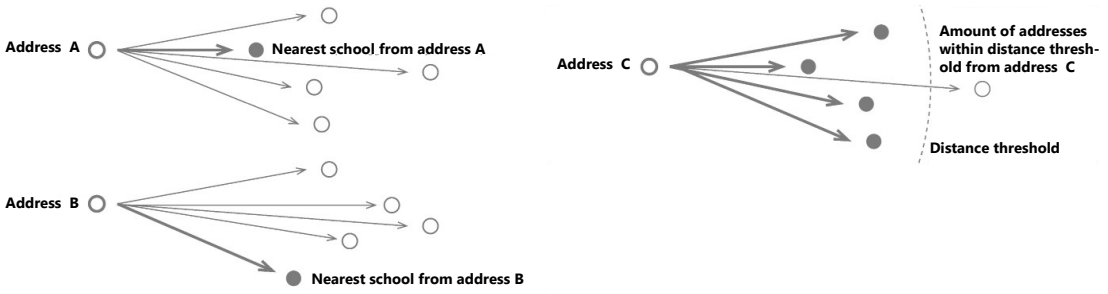

Figure 4.Attraction distance and attraction reach analysis; attraction can be of different kind, e.g.local markets, schools or public transport stops

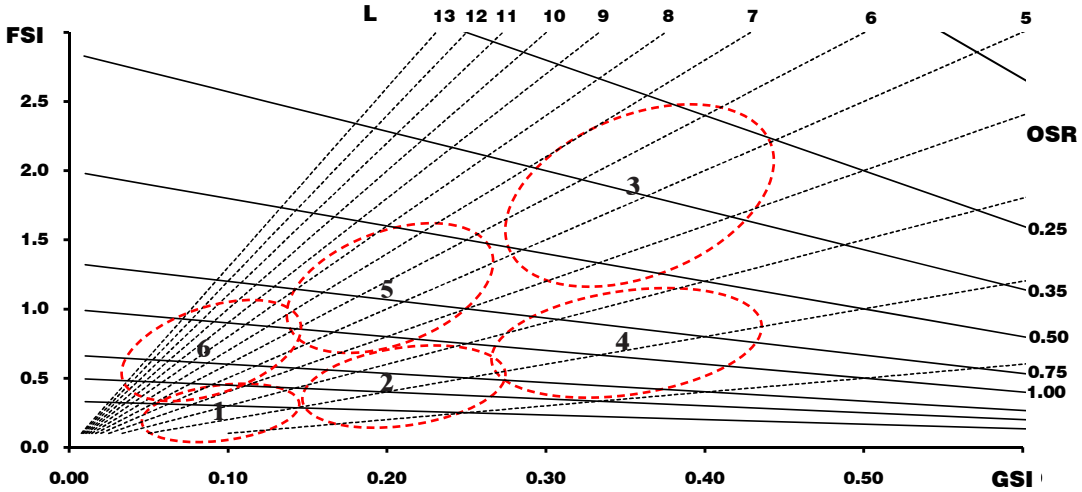

Figure 5.Spacematrix with clusters of building types: 1. spacious low-rise (mostly villa); 2. compact low-rise (rowhouse); 3. dense mid-rise (closed building blocks); 4. dense low-rise; 5. compact mid-rise; 6. spacious mid-rise (strip and point buildings). See Berghauser Pont et al. 2019 and the Fusion Point report ´Teorier om stadsform för att mäta städer´ for more details.

Built density

The concept of density is important for urban design and planning, but the definitions and the use of the concept has varied greatly through modern history. In its essence it is rather simple and can be described with the expression A/B where the nominator *A* can be population, number of dwellings or floor area and the denominator *B* is the plan area for which density is calculated (i.e. plot or neighbourhood). Berghauser Pont and Haupt (2010) developed a multi-variable method to measure urban density that is able to describe urban form through density metrics. This is what is referred to as the Spacematrix method. The variables included are Floor Space Index (FSI or in Swedish *exploateringstal*), compactness (GSI or in Swedish *marktäckning*), number of floors (L) and spaciousness (OSR or in Swedish *friyte-tal*).

This set of four variables (FSI, GSI, L and OSR) can be represented in a scatterplot where typical building types have shown to cluster with each a unique density profile described by the combination of FSI, GSI, OSR and the number of floors. Two variables are enough to define the position in the scatterplot and thus, to know what

building type dominates an area. In the Urban Calculator, density is calculated using the measures of accessibility. The total amount of built up area (footprint buildings) and the total amount of gross floor area (GFA or *BTA* in Swedish) is calculated using attraction reach. This value is used as nominator *A* in the simple fraction A/B. The area of land that can be reached is used as denominator *B*.

Building and street types

The building types that are defined based on their density-metrics profile are used as selection criteria for the search in the reference database of the Urban Calculator. Besides building types, the search is driven by the centrality profiles of the streets of the non-motorised model. These street types are defined based on the centrality values measured in ten different scales, from the local scale at 500 meter to a city scale of 5 km and all scales in between (in total 10 radii are used). It has been shown that the combination of street and building types can explain more than 50% of pedestrian movement in cities (Berghauser Pont et al. 2019). When a new street is added in the Urban Calculator, centrality and density are analysed, the corresponding typology is defined and relevent references from the database are presented. ´Relevance´ is thus defined as having similarities in their street centrality and built density profile.

Multiple scales of analysis

All analysis discussed here (i.e.centrality, accessibility and density) can be calculated at different radii to describe configurational characteristics at different scales. Metric radii have been shown to be effective in capturing different modes of movement. Higher radii correspond to vehicular movement and lower radii corresponds to pedestrian movement. These measures can be overlapped to identify spaces with multi-modal and multi-scale movement potential (Space Syntax Methodology, UCL). The importance of these multiple scale analys have been put forward by Hillier and

others as described in Legeby (2013): *"The notion that cities were constructed to be interfaces between scales of movement, creating an interface between inhabitants and strangers or between locals and non-locals (Hillier and Hanson 1984; Hillier 1996; Peponis et al. 1997) that is argued to be highly relevant from an urban segregation perspective."*

When developing the Urban Calculator, we tested whether fewer scales could still describe the street profiles and found that using three radii (i.e. 1, 2, and 5 km), gave 90% accuracy, meaning that with just these 3 scales in Gothenburg we can match the street types developed using originally 10 radii. Therefore these three scales are chosen for the analysis of street centrality, while for the analysis of accessibility and density, the scale that most people are willing to walk, approximately 500 meters walking distance (Gehl, 2010), is used.

URBAN CALCULATOR

Before presenting the Urban Calculator in detail with all its functionailities, we want to highlight that, as with any new tool developed, there are many parts that could and should be developed further. Within the time-frame and financial budget of the project (including the support of the Swedish Environmental Protection Agency), we have focused on developing all main functionality of the tool and therefore there are details in each step that can certainly be optimised and improved. You can download the latest version of Urban Calculator via the SMoG website: *https://www.smog.chalmers.se/*.

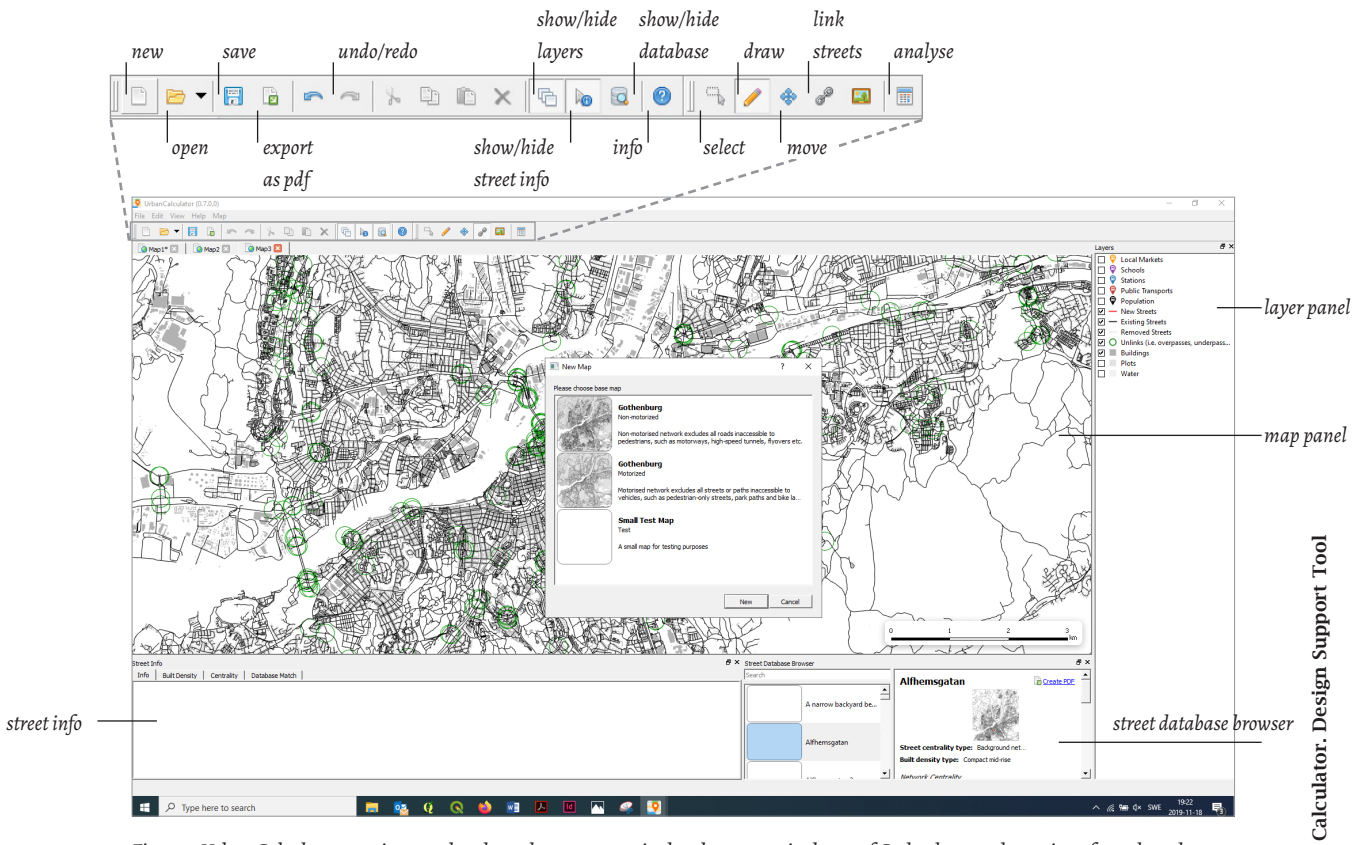

Figure 6.Urban Calculator, opening panel to choose between motorised and non-notorised map of Gothenburg and overview of panels and functions (see for details appendix 2)

After starting the tool, the user can open a map of choice (Figure 6). For now this is limited to the motorised or the non-motorised map of Gothenburg. Be aware that the choice for the type of map effects all analysis done later. The screen is divided in four panels: the map, the layer panel, street info and the database browser. A short description of function and an overview of map layers is given in Figure 6, but for a more complete overview, see appendix 1.

The user can add new streets to the network layer, which are visible through the distinct red colour (Figure 7). The existing streets are shown in black and removed streets in grey. When streets are added and they cross an existing street, unlinks are automatically created. This means that it is assumed that these new streets do actually *not* cross, but are under- or overpasses. The user has to actively remove the unlinks in case the intention is to connect the streets at the crossing. Information about streets can be provided by selecting a street with the "info" icon.

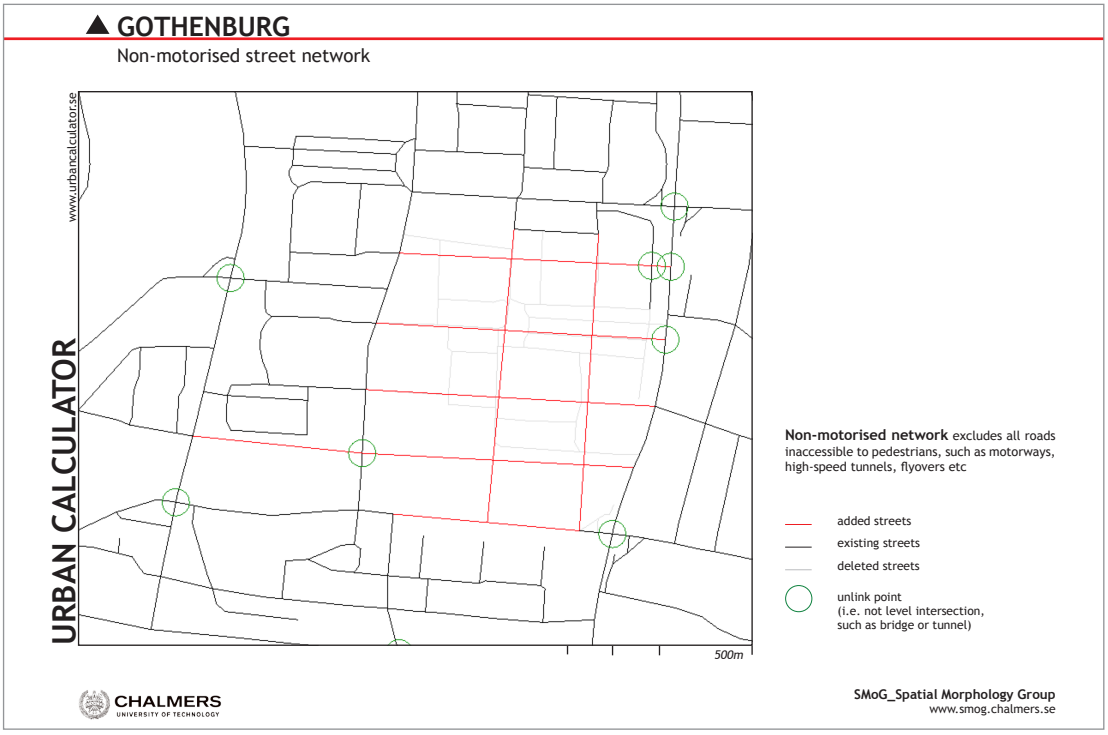

Figure 7.Urban Calculator adding new streets and removing unlinks and street info (see Figure 8a-c below)

Besides facts of the street itself, the user receives information about its values in relation to all streets in Gothenburg (the difference between the black and white bars in Figure 8a). Furthermore, the density values are depicted in the Spacematrix scatterplot where, besides the density of the selected street, also references streets with similar density and centrality are shown (Figure 8b). Be aware that the density of the street means the density of the street surrounding defined by the 500 meter walking distance as discussed in the former chapter. The centrality values could potentially also be visualised in a diagram showing its values throughout the three different scales. This feature is, however, not yet implemented. Finally, the reference database can be used to find other streets with similar density and centrality values (Figure 2).

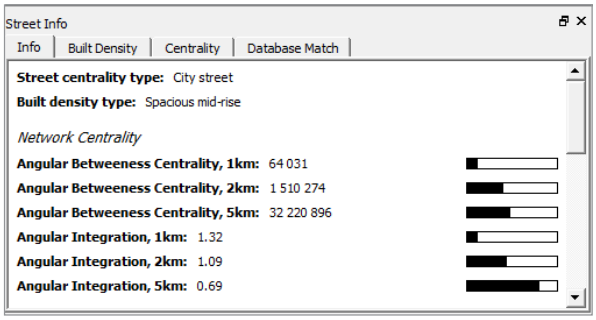

Figure 8a. Street info: measures

- *Information is provided for centrality, accessibility and density*
- *Both absolute values and relative values in comparison to the rest of the city are given*

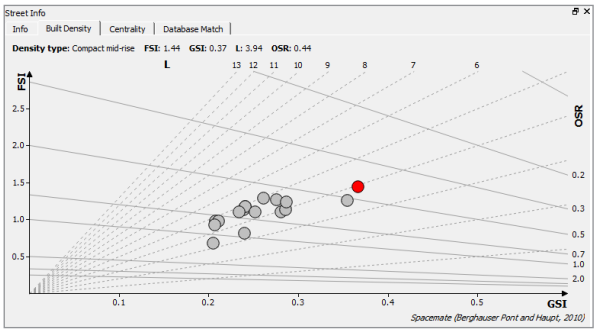

Figure 8b. Street info: Spacematrix

- *Density is shown in the Spacemate scatterplot where the red dot shows the value of the selected street*
- *The grey dots show similar streets in Gotheburg*
- *By clicking on one of the dots, information of that reference street are given*

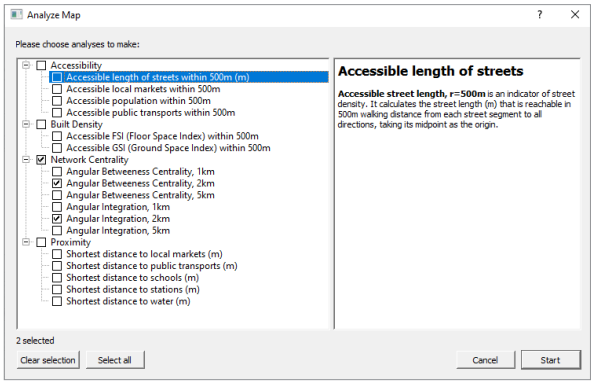

Figure 8d. Street info: reference output PDF

- *The analysis panel allows the user to choose a selection of analysis or all analysis can be chosen at once.*

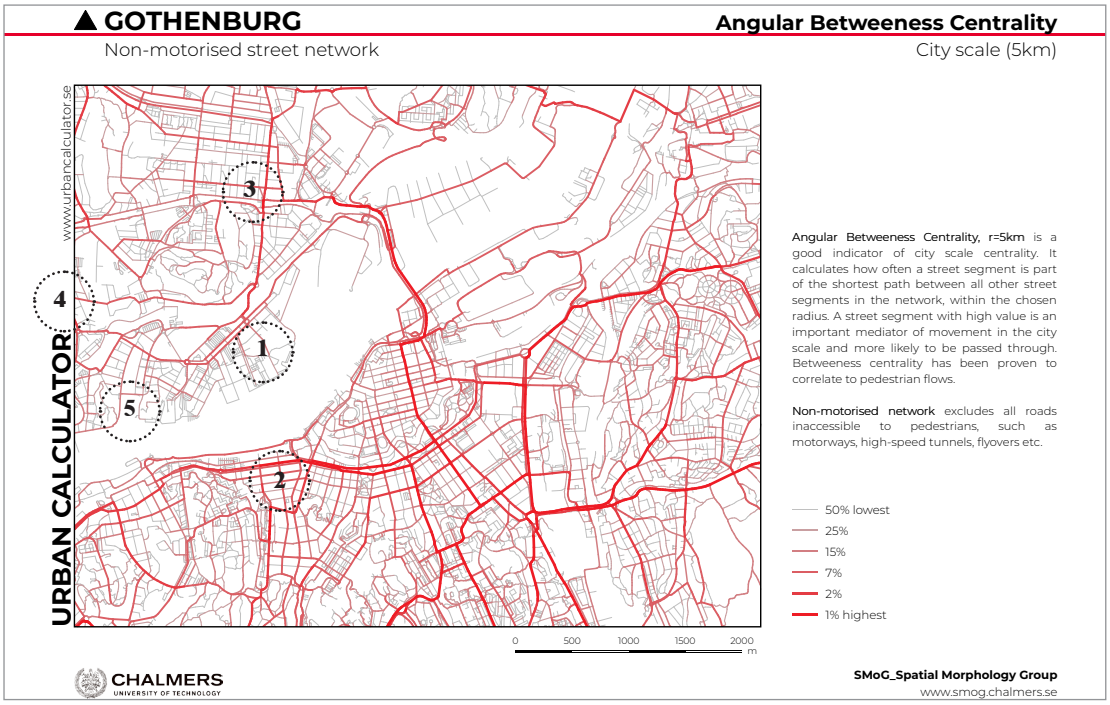

Figure 9.Urban Calculator analysis output of current sitation (betweenness centrality 5 km)

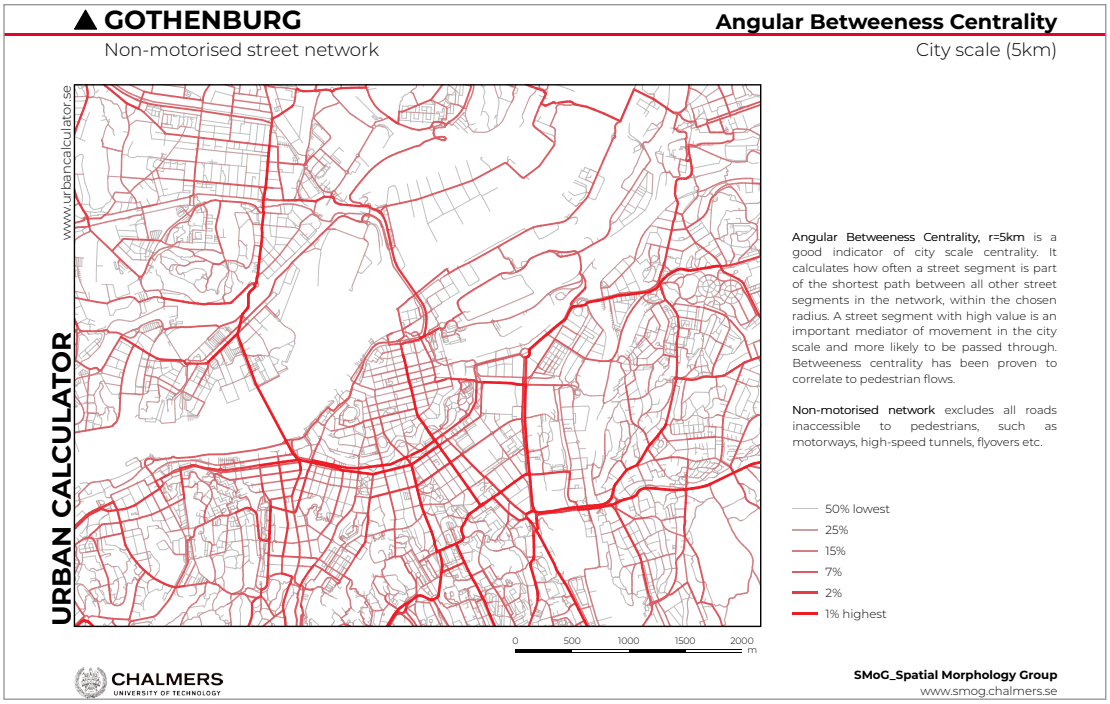

Figure 10.Urban Calculator analysis output with new bridge (betweenness centrality 5 km)

Next, the user can analyse the existing map or the modified map by activating the analyse icon. The analysis panel appears where a selection can be made of relevant analysis (Figure 8d). All can be selected at the same time, but be aware that the centrality analys on the scale 5 km can take some time (still, only a few minutes).

The results of two analysis shown in Figure 9 and 10 show how a new bridge in Gothenburg increases betweenness values for the added bridge and better links Järntorget (2) with Lindholmen (1). This strong line continues all the way Kvillebäcken in the North (3) and Lundby in the West (4). Besides these long and strong connections, more locally, Sannegårdsskajen (5) increases its betweenness as well as further increase the betweeness values in Första till Tredje Långatan (2).

All analysis can be run and exported as PDF. The output maps include, besides the map, information about the type of analysis and scale as well as a legend and scale bar. In Figure 11 the result of the density (FSI) analysis is shown

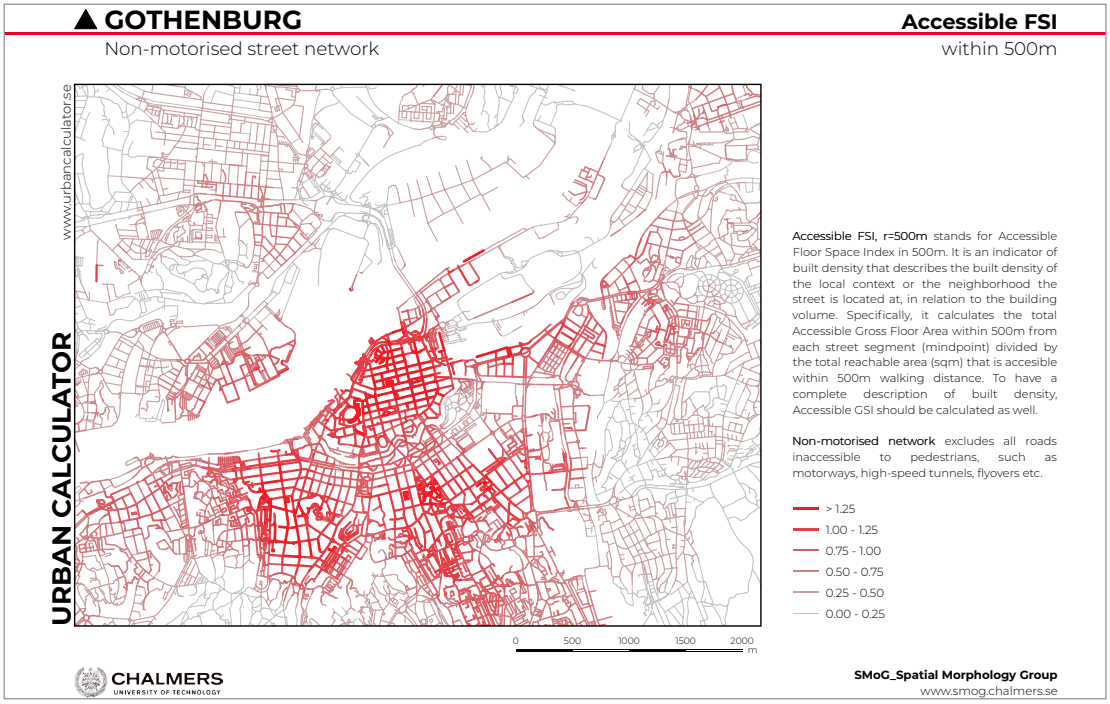

Figure 11.Urban Calculator analysis output density within 500 meter walking distance

TEST PANEL RESULTS

We organised three sessions with the test panel with two main goals. First, mapping the needs from the different users within two organisations working with urban development in Gothenburg, prior to the tool development. Second, test the tool while developing the different functionalities. The two organisations represented by the test panel are Älvstranden AB and the city of Gothenburg (SBK and GIS department). In appendix 3 the names of participants and other details of the reports of the test panel sessions are given. Besides the test panel, the tool was tested in education with 70 bachelor students using the newest version of the Urban Calculator in a third year course at Chalmers.

Mapping the needs prior to development

We defined questions to gather information from the test panel. Below, we first present the questions and then provide an overview of the results.

- What kind of spatial analysis or design tools do you currently use?

A variety of tools is used by the participants (i.e. Autocad, Sketchup, GoCart, GIS, FME, PST, Metastats, City Engine, Spacecalculator) and some do not use any tool at all. What is clear from this inventory, is that there is a divide in (i) participants that analyse, GIS experts using GIS including PST and (ii) participants that draw plans, architects and planners using Autocad and Sketchup. Besides the possible problem with this divide between design and analysis, also a practical problem was raised: the conversion and adaptation of files and formats from Autocad to use in GIS.

- What makes you use or not use a tool?

Most often mentioned is that the tool sould be easy to learn and use with a user friendly and nice interface. Familiarity with similar softwares could help achieving this. The first impression and first trial plays a significant role. The tool should be able to give results fast and should give visually powerful output to communicate with non-experts. Further, the tool should be free (i.e. open-source) or have a reasonable price that can be judged before buying based on a free trial time.

An important point made was that it should be clear when and where the tools is to be used and how results should be interpreted. In relation to this, the terms used need to be understandable.

After presenting the three main functionalities of the tool (i.e. editing, analysis, reference database) and the main spatial analysis included in the tool (i.e. centrality, accessibility, density), we asked the panel to react on the following questions.

- Which functions and analysis are most useful for you?

Most participants highlighted the analysis as the most important function of the tool and the reference database as second. The argument for the analysis related mostly to the need to get insight in what was called “the big picture” that can highlight the potentials of an area. The argument for the database was to communicate to others, mostly politicians and other leaman.

In terms of analysis, all agreed that centrality analysis was most important, while the other two types of analysis were considers equally important. The priority given for the type of attracions that should be included in the analysis was in order of importance: public transport stops, schools, parks and public space (including water

front), living and working population. The GIS expert of the city of Gothenburg had an important voice in providing this overview of the priorities and needs, because she is asked to do such analysis for others on a daily basis. Many of the prioritised attractions are related to standards where planners have to meet certain levels such as minimum distances to bus stops or schools and the amount of green area per person.

- What kind of projects would the tool be relevant for (type and size)?

All levels of planning were mentioned by the participants from detailed planning with development plans (*detaljplan* in Swedish) to compreenisive planning (*översiktlig planering* in Swedish). Another application of the tool mentioned was to use it for the re-evaluation of old development plans and prioritisation of scheduled development plans based on their overall impact.

- What kind of information should be include in the output?

Besides a short description of measure and scales and legend, an indication should be given of what the resulting value of density or centrality is in relation to the city as a whole (i.e. upper or lower limit or in the middle). Besides centrality, accessibility and density, the following information was mentioned as informative for the reference database: street width, building height, actual flow of e.g. people, buses, cars.

The last question related to possible other functionalities that we have not yet considered. These are not yet implemeted in the current Urban Calculator, but should be seen as possibilities for further development.

1. Export the map in shape file with coordinate system, so that they can easily be imported in other GIS software.
2. Add a background aerial photo and the possibility to upload a background image yourself.

3. Density analysis on other scales than the walkable neighbourhood such as block or plot density
4. Possibility to change attributes of buildings like average building height, or gross floor area (*BTA* in Swedish)
5. Possibility to estimate gross floor area (*BTA* in Swedish) and from that roughly estimate population density for new buildings and development areas

Evaluating the tool while developing

We provided the panel with a brief overview of main functions of the tool (see appendix 1). Then the panel did six small exercises that were discussed afterwards.

1. Start a new project.
2. Run the analysis for 1, 2, 5 km (while running, go to TASK 3)
3. Add a bridge over Älven and check unlinks so that they correspond with your bridge solution. Then, run the analysis for 5km, export PDF for the 5km-analysis. Save the UCmap.
4. Draw a grid in Heden connecting existing streets across the field and run the analysis. Extend existing streets and remove streets that should be changed. Add new streets and run the analysis for 1km and 2km. Export PDF for the 2km analysis. Save the map.
5. Test the performance of a new design. Add a map as background image and rescale it so that it fits the base map (e.g. Strukturplan med kollektivtrafik Utkast 20170329.PNG).
6. Choose your own location and make a test by adding or removing streets. You can also use the image in task 5 and test the Sttrukturplan. Don't try to draw the whole map, but the main connections. Run the analysis for all scales. Export PDF for the 1, 2 and 5km-analysis. Save the map.

- What are the positive features of the new tool?

All agreed on the ease to learn and use the tool, also those who are not architects, nor gis-experts and have never used such tool before. Some comments were: “Very straightforward”; “You get the hang of it very fast”. The tool is very smooth when zooming in and out and the output images are powerful. They agreed that it seems very interesting and useful and that they would certainly use it.

- What are the negative features of the new tool?

The analysis gets slow when more analyses are running at the same time, but it still runs much faster than other analysis software in GIS.

We also discussed features that were not implemented at the time of the test panel such as the undo/redo function and possible bugs in the tool that are listed in appendix 3. In summary, the comments are much about clarity of the editing functions and the quality of the output files (especilly colours were discussed a lot), including an export function to other GIS softwares.

Two bigger additions that were suggested include, first, an introductory page with: a) a short manual with the basic functions, b) explanation of the scales and measures, c) drawing tips with examples of how to best draw the lines, unlinks etc, d) state what the tool does not do, so that it will not be used in a wrong way. Second, it was suggested that second stage analysis would be helpful, which visualises and highlights the effects of an intervention in terms of the changes and where they happen most.

APPLICATIONS AND EXTENSIONS

Summarising, we have developed a tool that fullfills many of the ambitions set out at the start. We want to repeat the main usage of the tool here again. It can and should be used as design support instrument and should thus not replace spatial analysis by GIS experts. The drawing of new streets are more crude than what can be accomplished in regular GIS tools, but is accurate enough for testing different scenarios. The main target group is municipalities and other actors developing spatial scenarios for urban development. The feedback given by the tool is supportive for various stages in the planning process, from the development of regional plans and comprehensive plans (*översiktsplan*) to the level of development plans (*detaljplan*).

For the further development of the Urban Calculator, we propose to collaborate with the interactive platform of the Digital Twin City Center that will be developed in the coming 5 years at Chalmers University of Technology. Such Digital twins already exist for other cities worldwide (e.g. Singapore, London). Although the core idea is to create a real-time virtual mirror of the city as is now, in order to forecast changes in the real city by modeling them in the virtual city, design support tools are needed to develop future scenarios. In combination with the longitudinal model developed in a parallel Fusion Point project, this could add a unique feature in Gothenburg's Digital twin that can look backwards and forwards.

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APPENDIX 1. List of functions

Draw/Edit

 Add line

Snap (end point, mid points)	Implemented as “snap to closest line” or “snap to end point”. Unlinks are always added when two lines cross, except with endpoints. Hold “Ctrl” to disable snapping.
Delete	First “select”, then “Delete”.
Move line	Implemented so that the line always keeps its links to other lines; with “Ctrl” you can detach a line from existing lines.
Move endpoint	Use “Ctrl” and move end line, to snap back to an existing endpoint, switch off “Ctrl” function.
Move current selection	You can box select or click select separate lines and move them.

 Select line

Select end point	Using “Ctrl”.
Box select (more lines)	Select more than one line with same button as select line, with “Ctrl” you can add to the selection, with “shift” you remove selected lines.

 Link/Unlink — Removing unlinks one by one; you cannot manually add unlinks.

Interface	
Zoom	Scroll mouse wheel.
Pan	Press mouse wheel.
 Add image	The image is not saved when you save the map.
Edit image	Only scaling now (rotating, pinning, freeze scale ratio, adjust colour and brightness not implemented).
Basic functionalities	
 Load/Save as	Format .ucmap
Quick access to recently opened files	See Load/Save as (also in drag down menu)
Export analysis to PDF	Only analysis can be exported as PDF; exporting base map not implemented.
 Undo/redo	
Export as DWG/DXF/TAB/Shape	Not implemented yet.
Analysis	
 Analysis	
Visualisation/Colour ranges	Method for showing ranges is fixed % (user choice of colour range not implemented).

Layers (see for details about sources, appendix 2)

- Local markets (OSM)
- Schools include primaru schools (OSM)
- Stations include all bus and train stations (OSM)
- Public transport include all bus, tram and train stops (OSM)
- Populations includes the residential population in celss of 100x100m (SCB)
- New streets are streets added by the user
- Existsing streets (source: NVDB and OSM)
- Removed streets are streets deleted by the user
- Unlinks define where two crossing streets are in reality a bridge or tunnel
- Buildings (source: xx)
- Plots (source: xx)
- Water (souce: xx)

APPENDIX 2. map sources

Streets. The street network is divided in two models where one represents the motorised network and the other the non-motorised network. For the motorised we used the NVDB (*Nationell Vägdatabas*), downloaded from the national road database (*Trafikverket*; https://lastkajen.trafikverket.se); for the non-motorised the OpenStreetMaps (OSM) was used, downloaded from openstreetmap.org (http://download.geofabrik.de, date of download 29-4-2016), because the NVDB did not provide enough detail for the non-motorized network. Some editing and generalisation procedures, such as removing duplicate and isolated lines, snapping (threshold used was 2m) and generalizing (threshold 1m); see Berghauser Pont et al. (2017) for more details.

In the motorised network, all roads that are accessible for cars are included. They are represented with one line irrespectively of the number of lanes, except from motorways and highways which are represented with two lines, one for each direction, again irrespectively of the number of lanes. The non-motorized models include all streets and paths that are accessible for people walking or cycling, including those that are shared with vehicles. All streets where walking or cycling is forbidden, such as motorways, highways, or high-speed tunnels, are not included in that model.

Buildings. The building polygons (*fastighetskartan bebyggelse*) are downloaded from Lantmäteriet. Height data was extracted from a laser dataset, also from Lantmäteriet (http://www.Lantmateriet. . See Berghauser Pont et al. 2017 for details.

Plots. The plot data is based on the cadastral properties in Sweden (Fastighet maps from Swedish Land registry (http://www.Lantmäteriet.se). Cadastral properties cover all types of land, including road and rail networks as well as water bodies. Water, roads and rail networks were excluded from the plot layer, using the same procedure in all cities; see Bobkova, et al., 2017 for details.

Local markets. The land use data is based on the point data from OpenStreetMaps and includes all kinds of functions except residential, industry and offices, namely: retail, education and public facilities, food and drinks, hotels, sports and culture, banks and health. These basic categories are used based on original OSM coding, where the first two digits of the code are related to general function, and the last two digits are related to subcategory of each class. The exact local markets included are retail and food (OSM coding 25xx, 23xx, see Table 1).

Schools. Schools include all levels, and kindergartens (OSM, Points of interest)

General Category and OSM coding	Subcategory (feature class)
Retail and service (25xx)	Bakery, beauty shop, beverages, bicycle shop, book shop, butcher, car dealership, car rental, car sharing, car wash, chemist, clothes, computer shop, convenience, department store, doityourself, florist, furniture shop, garden centre, gift shop, greengrocer, hairdresser, jeweller, kiosk, laundry, mall, mobile phone shop, newsagent, optician, outdoor shop, shoe shop, sports shop, stationary, supermarket, toy shop, travel agent, video shop
Food and drinks (23xx)	Bar, café, fast food, food court, pub, restaurant
Bank and atm (26xx)	Bank
Education and public facilities (20xx)	Art centre, college, community centre, courthouse, embassy, fire station, kindergarten, library, nursing home, police, post office, public building, school, town hall, university,
Hotels (24xx)	chalet, guesthouse, hostel, hotel, shelter,
Health (21xx)	Dentist, doctors, hospital, pharmacy, veterinary
Sports and culture (22xx)	Cinema, ice rink, night club, sports centre, stadium, swimming pool, theatre
Tourism and culture (27xx)	castle, fort, museum, theme park, tourist info, zoo

Table 1. OSM categories

Stations. Bus and train stations are included (OSM, Points of interest)

Public transport. Bus, tram and train stops and stations are included (OSM, Points of interest)

Water. Water bodies include sea, rivers and lakes (Lantmäteriet)

Population data. Residential population data comes from SCB (Statistiska centralbyrån) for grid cells of 100x100m . The data are updated annually and the latest set is from the 1st half of 2017 (1 Jan to 30 Jun).

The boundaries of the full model of Gothenburg is defined by the Urban morphological zones (UMZ) are defined by Corine land cover classes considered to contribute to the urban tissue and function (Figure 12). A UMZ can be defined as "a set of urban areas laying less than 200m apart" (http://www.eea.europa.eu/data-and-maps/data/urban-morphological-zones-2006).

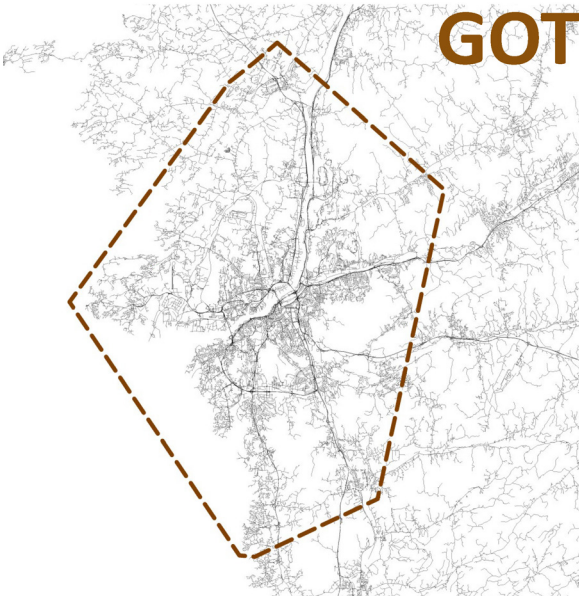

Figure 12.UMZ Gothenburg

APPENDIX 3. test panel reports

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Dates of the panel meetings

June 18, 2018

October 18, 2018

Tool evaluation by students

October 2019

See for the full reports of the seperate meeting the next pages.

Test panel 01 and 02

Members present: Malin (SBK), Shraddha (SBK), Javier (Älvstraden), Amanda (Intern, SBK)[1]

PROFILE	Malin	Javier	Shraddha
Familiarity with Space Syntax analysis and SMoG tools	High	Medium	None
Area of Expertise	GIS specialist	GIS specialist	Designer

Urban Calculator_Test Panel 2_181018

Members present: Andrea (SBK), Niclas (Älvstraden), Ashwin (SBK), Jacob (Älvstraden) [2]

PROFILE	Andrea	Niclas	Ashwin	Jacob
Familiarity with Space Syntax analysis and SMoG tools	High	None	Medium	None
Area of Expertise	Architect,Urban designer	Architect, Project leader (quality group, in charge for the design program)	Architect, Sketch architect	Project evaluation (sustainability factors)

1st ROUND OF QUESTIONS

SPATIAL ANALYSIS IN CURRENT WORKFLOW

- What kind of spatial analysis do you use?
- When in the design process?
- Do you evaluate your proposal(s)? Different alternatives?
- Do you do it yourself, in house, or buy it "outhouse"?
- What analysis tools do you use now? GIS, Autocad, others?
- If you're not using tools, why?

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- Do you use analysis? What kind of spatial analysis? What kind of tools do you use now?

Test Panel 1

	Malin	Javier	Shraddha
Tools used	QGIS, ArcGIS, PST, Mapinfo, FME, City Engine	QGIS, PST, GoKart (?), MetaStats	Modulor, Sketchup, Autocad, City Engine, SpaceCalculator (past)
Uses PST	Yes	Yes	No
Uses GIS in general	Yes	Yes	No

Test Panel 2

	Andrea	Niclas	Ashwin	Jacob
Tools used	Autocad	No design or spatial analysis software	Modulor, Sketchup, Autocad, SpaceCalculator (past), GoCart Daylight analysis software	No design or spatial analysis software
Uses PST	No	No	No	No
Uses GIS in general	No	No	No	No

Malin

Tools she uses:

- QGIS
- PST
- Mapinfo
- ArchGIS
- FME (Analysis not related to Space Syntax she does mainly in FME or in QGIS)

Other comment: Usually gets Autocad files as input and spends a lot of time trying to convert, edit and put them in the GIS model for analysis. Conversion and adaptation of files and formats to use in GIS and in analysis becomes an issue.

Javier

Tools he uses:

- QGIS
- Gokart (?): user friendly tool developed by SBK, with data for city areas, can measure a polygon, but analysis capacity very limited

- MetaStats: Indicators for density, inhabitants, shops, green areas, how many floors, how many parking, how many rooftops etc. To evaluate projects, one has to measure in QGIS to see if you meet the parameters. The parameters are guidelines.

Shraddha

Tools she and her group use:

- Autocad
- SketchUp (can easily load dwg), easily make 3d plans, add heights to buildings
- Modulor (plugin for Sketchup), easy to use tool, connected to SketchUp and Autocad, gives output such FSI-GSI on block scale, outputs also excel sheets with number and information
- City Engine: visualisation and analysis, set parameters to generate design solution (for example put rules of BTA), BUT you need to know a lot to use it
- Space Calculator in the past, to calculate density and get references

Other comment: New generation does not use Mapinfo, but only Autocad. Conversion and adaptation of files and formats to use in GIS and in analysis becomes an issue.

Andrea

Tools she and her group use:

- Autocad for design
- Mapinfo for analysis
- Traffic analysis
-

Note: She doesn't use the tools herself but works with people who use GIS and do Space Syntax analysis. She is familiar enough to reflect on the results. She also noted that she uses a lot of Traffic analyses, made by others.

Niclas

Tools he and his group use:

- They don't use any design or spatial analysis software
- Office (Excell, Powerpoint, Wod). He mostly works with excel tables.

Note: He is in charge of the design program and works with the Quality Group to take the projects to production. He also deals with the finances. He works with 'Liveable cities'

Ashwin

Tools he uses:

- Autocad
- SketchUp, for design and visualisation
- Modulor (plugin for Sketchup), easy to use tool, fast analysis. SBK asked for custom scripts.
- GoCart
- Space Calculator in the past, to calculate density and get references

Jacob

Tools he uses:

- They don't use any spatial analysis software for their project evaluations. They only use transport analysis results.
- Office (Excell, Powerpoint, Wod). He mostly works with excel tables.

Note: His specific work is to evaluate projects, for example to test the effects of where to place schools or shops and compare various alternatives. He noted that transport analyses come into the projects very early, almost as starting point.

- What makes you use or not use a tool?

Test Panel 1

	Malin	Javier	Shraddha
Reasons for selecting tools	Agree with Shraddha	Agree with Shraddha	-Easy to use, not complicated -Easy to learn, not much time to spend on learning a tool -User friendly, nice interface -First impression and first trial play a significant role Free, open-source OR reasonable trial time -Price for licences

Test Panel 2

	Andrea	Niclas	Ashwin	Jacob
Reasons for selecting tools	-Evidence-based design tool -Easy to learn -Easy to use -Not too complicated -Familiarity with similar software	-Easy to learn -Easy to use -Technical difficulties	-Economic reasons, Price for licences -Easy to learn -Easy to use -Fast -Visually powerful output to communicate with non-experts, the public or politicians -Legible -Words and terms should be	-He hasn't found the tool he needs for his specific work -Easy to learn -Easy to use -Clear as to where the tools is to be used and how the results should be interpreted

			easily understandable	

2nd ROUND OF QUESTIONS

VALUE OF THE NEW TOOL FOR YOU

1. Which parts of the tool are most useful for you?
    - Analysis output
    - Database with references output
    - Network analysis
    - Density analysis
    - Accessibility analysis
2. What kind of projects would the tool be relevant for? Type and size.
3. Would you use the tool yourself? What could be the main reasons for not using the tool? (was answered in 1st round)

- **Which parts of the tool are most useful for you? Relative usefulness, priorities**

Test Panel 1

	Malin*	Javier	Shraddha
Prioritise Analysis or Reference database	References (because analysis can be done elsewhere)	Analysis	Analysis
Prioritise Types of analysis	Network analysis Density Attraction distance Attraction reach	Network analysis Attraction distance Density	Network analysis Density (because it affects the program) Attraction distance Attraction reach
Prioritise Groups of Attractions for Accessibility analysis	-Bus stops** -Schools (pre-school and primary school up to group 9) -Parks and public spaces -living and working population More specific questions: local healthcare centres	Plus -distance from schools to gym, athletic centres	Plus -public spaces in general (including waterfront, squares, parks, pedestrian streets)

Test Panel 2

	Andrea	Niclas	Ashwin	Jacob

Prioritise Analysis or Reference database	Analysis (because she needs the big picture when working wth the comprehensive plan) BUT for Strategic planning she needs everything	Analysis (because this will show the impact of one development plan to other areas, prioritise the development plans and re-evaluate old detail plans)	References (because it is the only way to get through to other people and so far they only use references on Traffic flows)	Analysis (because this shows the big picture and highlights the potentials of an area)
Prioritise Types of analysis	Network analysis	Network analysis Attraction distance	Network analysis (because it can guide the program)	Network analysis (highlights potentials) Attraction distance and reach (make the program)
Prioritise Groups of Attractions for Accessibility analysis	What is already scheduled	What is already scheduled	What is already scheduled	What is already scheduled

*Malin has a good overview of the priorities and needs because she is asked to do analysis for others.
** These are also related to standards they have to meet in design (e.g. minimum distances to bus stops or schools, green area per person, population is needed to estimate maintenance needs for parks etc)

- What kind of projects would the tool be relevant for? Type and size.

Malin -

Javier
Development areas which have to be seen in the whole context. Detailed development plans (detaljplan) and structural plans. Approximately the size of a neighbourhood

Shraddha
Development areas, Detailed development plans (detaljplan)

Andrea
Comprehensive plan, strategic planning

Niclas

Development plans which have to be seen in the whole context. Analysis will show the impact of one development plan to other areas and the whole city. Also, detailed development plans (detaljplan) are old (e.g.1990) and the surroundings of the respected aras have changed; these need to be re-evaluated in the current context. Analysis can help re-evaluate and prioritise scheduled development plans based on their overall impact.

Ashwin

Development areas, Detailed development plans (detaljplan)

Jacob

Evaluation of development plans in respect to the whole city and in realtion to each other.

3rd ROUND OF QUESTIONS

ANALYSIS INCLUDED IN THE TOOL

Network analysis*

- What is it you have to solve?
- What scale most relevant? local, meso, global (answered in 2nd round)
- When would this be most relevant in the design process?

Density analysis

- What is it you have to solve? Requirement (politics, developer)? Limits from regulations?
- What scale most relevant? plot, block, project
- When would this be most relevant in the design process?

Accessibility analysis

- What is it you have to solve?
- What analysis is most relevant, that is, effects your proposal most? Distance to what? Accessibility of what?
- When would this be most relevant in the design process?

2. What kind of information should the reference database give you? Now it includes centrality and density, plus an image and map.

*Most of the questions of the first part were answered in the 1st and 2nd round. Here they answered question 2 and also gave suggestions for added functionalities and feedback on the functionalities that were presented (see next page).

- What kind of output should analysis give you? What kind of information should the reference database give you? Now it includes centrality and density, plus an image and map.

Test Panel 1

	Malin	Javier	Shraddha
Analysis output (+ Image-map Scale Legend - colour scale)	Agree with Shraddha -indication of where in the range is the value, close to the upper or lower limit or in the middle etc	-	-Short description of measure and scales -Colour scale legend in low-high -Settings
References output (+ Photo Map FSI, GSI Bet, Int in scales)	-	-	-Street width -Building height -other data like access to shops etc

Test Panel 2

	Andrea	Niclas	Ashwin	Jacob
Analysis output (+ Image-map Scale Legend - colour scale)	What is already scheduled	What is already scheduled	What is already scheduled	What is already scheduled
References output (+ Photo Map FSI, GSI Bet, Int in scales)	What is already scheduled	What is already scheduled	-Information on flows (cars, people, buses, bikes)	What is already scheduled

- Other functionalities they proposed or highlighted*

Malin:
-Export the map in shp or at least export the layer of added/edited lines with coordinate system, so that they can easily import to their shp, .tab file (or dwg?) and they don't have to redraw their design proposal from scratch to make a more elaborate PST analysis for example

Javier:
-Save alternatives (this can be done already)
-the drawing should be made easier if you have a neighbourhood to draw

Shraddha:
-Background aerial photo AND possibility to upload a background image of their sketch/drawing, so that they don't have to draw their design proposal from scratch. The image should be editable, so that they can drag and fix the size to fit the scale of the drawing
-FSI, GSI also on block level or on parts of the block (street facades)
-We should predefine relevant settings (radii, colour ranges etc) and give short descriptions for those who are not familiar with the measures and settings
-possibility to change attributes of blocks like average building height, or BTA
-possibility to estimate BTA and from that roughly estimate population density for new blocks and development areas

*NOTE: Because the TEST PANEL 02, was called after the Tool was quite developed, they did not have suggestions of functionalities that were not already scheduled or implemented at the time. They confirmed our priorities and were very much aligned with suggestions of TEST PANEL 01.

Test panel 03

The aim of the second meeting with the test panel was to test the latest version of the Urban Calculator and receive feedback concerning the different functionalities of the software and its user friendliness, one of the main challenges for the tool. The software was downloaded by the test panel beforehand (Version 0.4.1.1) using the following link:
https://www.xmnsoftware.com/secure/urbancalculator/index.php?action=download

General info on the Panel:
Members present: Niclas Malmeling (Niclas.Malmeling@alvstranden.goteborg.se), Javier Falla Arce (Javier.Falla.Arce@alvstranden.goteborg.se), Shraddha Kapri (shraddha.kapri@sbk.goteborg.se), Malin Klarqvist (malin.klarqvist@sbk.goteborg.se), Jacob Lundkvist (Jacob.Lindkvist@alvstranden.goteborg.se), Ashwin Karjatkar (ashwin.karjatkar@sbk.goteborg.se), Zuzanna Komorowska (zuzkom@chalmers.se)

Not present: Jonas Bäckström (jonas.backstrom@sbk.goteborg.se); Åsa Vernersson (asa.vernersson@alvstranden.goteborg.se), Andrea Hulting Gustavsson (andrea.hulting.gustavsson@sbk.goteborg.se)

Previous experience:
4 (2 gis-experts and 2 architects) had some experience with analytical tools in general
The 2 gis-experts also know PST quite well
There were 3 people that never used anything like that.
One was not an architect, so had no experience of drawing.

Test tasks
We provided the panel with a brief overview of main functions of the tool (see appendix). Then the panel did six small exercises that were discussed afterwards.

1. Start a new project.
2. Run the analysis for 1, 2, 5 km (while running, go to TASK 3)
3. Add a bridge over Älven and check unlinks so that they correspond with your bridge solution. Then, run the analysis for 5km, export PDF for the 5km-analysis. Save the UCmap.
4. Draw a grid in Heden connecting existing streets across the field and run the analysis. Extend existing streets and remove streets that should be changed. Add new streets and run the analysis for 1km and 2km. Export PDF for the 2km analysis. Save the map.
5. Test the performance of a new design. Add a map as background image and rescale it so that it fits the base map (e.g. Strukturplan med kollektivtrafik Utkast 20170329.PNG).
6. Choose your own location and make a test by adding or removing streets. You can also use the image in task 5 and test the Sttrukturplan. Don't try to draw the whole map, but the main connections. Run the analysis for all scales. Export PDF for the 1, 2 and 5km-analysis. Save the map.

GENERAL POSITIVE COMMENTS

1. Very easy to learn and use. Very straightforward. You get the hang of it very fast (said all, also those who are not architects, nor gis-experts and have never used such tool)
2. Very intuitive (said one architect)
3. Powerful image in the analysis and output (said one architect)
4. Very smooth, fast zoom (said gis expert)
5. Seems very interesting and useful (said all)
6. Very exciting (said one architect)
7. Very good first impression (said all)
8. Would use it (said all)

GENERAL NEGATIVE COMMENTS

1. The analysis gets slow when more analyses are running at the same time (said one architect and our youngest user-student, who started making things very fast). But it still runs much faster than other analysis software (said the gis-expert). Also, depends on the computer.

FEEDBACK-SUGGESTIONS

a. Possible bugs?

- In one case the analysis windows showed the same results in all scales, although the pdf output was correct.
- In one case it freezed and needed restart. The laptop might be to blame for that. Not sure.
- Jpg image could not be imported, only png
- Different computers showed different line widths in the PDF output legend and the differences were lost. Maybe it is the pdf export, and we should have an image file export. Or maybe we should add the legend as an image window in the output, not as vector lines. The legend showed the problems, otherwise the Output was as expected.

b. Confirmed things we already planned

- Add Undo-redo
- Should be able to save the image placement and scale. To have a reference link would be enough, as we have discussed.
- Should be able to pin down the image and lock/unlock scale to make the adjustment easy
- Add legend in the drawing window. The Unlinks cannot be understood without it and they could create confusion
- Add an introductory page (see d. for suggestions on that)
- The 'hidden' keys, like the use of the ctrl and the pan were not easy to guess. All the other things were easily found without looking at the instructions. (most started drawing immediately and did not consult the instructions, making clear that they did not use the hidden keys. We had to tell them this was possible, but even then it was a bit hard to use them)
- Add Pan button

c. New suggestions for changes and smaller additions

1. Save view. To be able to save a view in all windows, so that both the drawing window and all analyses windows show the same part of the map. Or add Lock/unlock view
2. Should be able to save the Analysis map as well.
3. Export multi-layer pdf with all analyses output, map output etc as layers. Interactive pdf
4. Move function. Grab and move detached line should be the default action. (risk is that you can unlink lines and that can cause problems for the analysis)
5. In moving endpoints, the line whose endpoint will move first should be highlighted. The user should be able to choose which endpoint to move out of the 4 in an intersection. Something similar is in SketchUp
6. Adding a line exactly on top on another line is now possible. One of the users actually did that. This could create problems with the analysis. We should talk about how to deal with this possibility, maybe not allow it.
7. Instead of an aerial photo, add background GIS layers of water, buildings, plots etc to help with the drawing. For example, grey city maps. To be able to show/hide, lock/unlock layers.
8. Make sure that the drawing lines are visible on top of all possible imported images. We have two possible suggestions we can discuss (this was actually not mentioned by the panel, but they did not draw on top of an imported map)
9. Background images should be optionally visible in the analysis windows as well. Show/hide (maybe also the other GIS layers can be shown in the analysis result and switched on/off, see note 6 above)
10. Give names to the Analysis windows, in relation to the Map name (Map ame_Analysis1,2,n). There was confusion with the numbering of Map and Analysis windows. Each Analysis should match the respective Map, so that the user keeps track on which Map version is analysed in the Analysis window.
11. Information of the analysis (explanation of measure, scales etc) should also be visible in the analysis window. The user should not wait for the output to understand what he is analysing. It can also be a pop-up window when you open/activate one of the analyses
12. If an image is georeferenced with the same reference system as our map it should be added in the right place directly (but that does not fix the scale). Or to pick 3 points in the map to connect to 3 points in an image, that way one inserts and scales at the same time. I think georeferencing works in GIS like that. But this was not considered a very important addition.
13. Have line widths AND colour fading in the red colour ranges. Sometimes they could not tell which line belonged to which range. The width differences were so subtle that they couldn't understand all ranges, especially the middle reds (also, Lars had the same comment) They asked why we didn't use the Space Syntax colour scale. Either way, we should make each range more distinct.

d. Big additions

1. Add Introductory page with: a) a short manual with the basic functions with button images plus explanation etc, b) explanation of the scales and measures, c) drawing tips

with examples (figures) of how to best draw the lines, unlinks etc, d) state what the tool DOES NOT do, so that it will not be used in a wrong way. Add disclaimers, 'the tools is NOT for this and that'. It should be clear when the user should move to PST and that the UC is not the tool to do certain or all things.

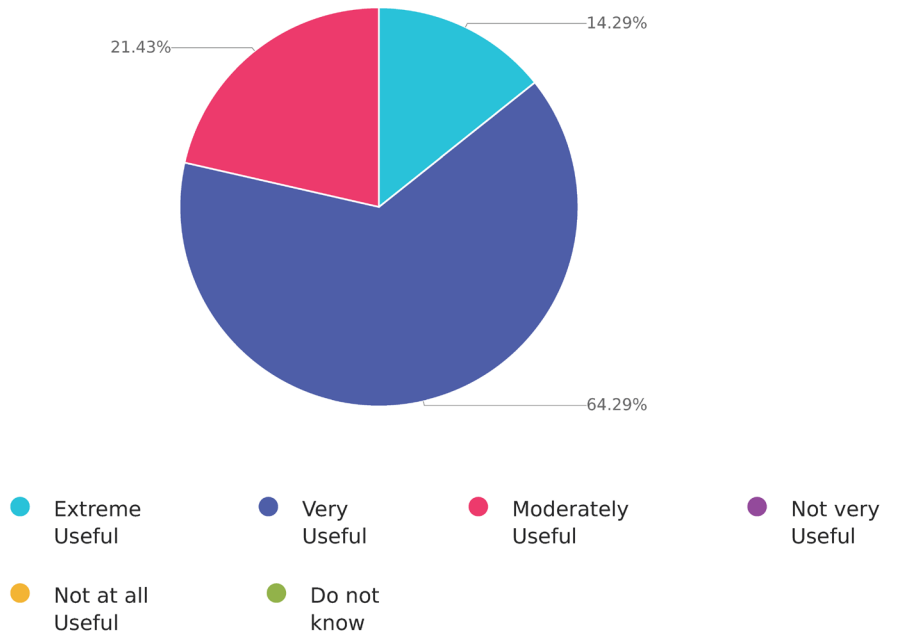
   a. This can be a separate page of a new window that one can also choose to deactivate so it does not show again when you open the tool (for regular users this info is not relevant, maybe even annoying)

2. Add 2nd stage analysis which visualises and highlights the effects, the changes and where they happen most. Have a PLUS and a MINUS result map in all scales. We have discussed this earlier and it was mentioned by the panel. Overall, how the effects can be best shown in the analysis window, also based on the zoom, was discussed a lot.

Student evaluation

How useful was the Urban Calculator in understanding the configurational properties (´läge´) of the study area?

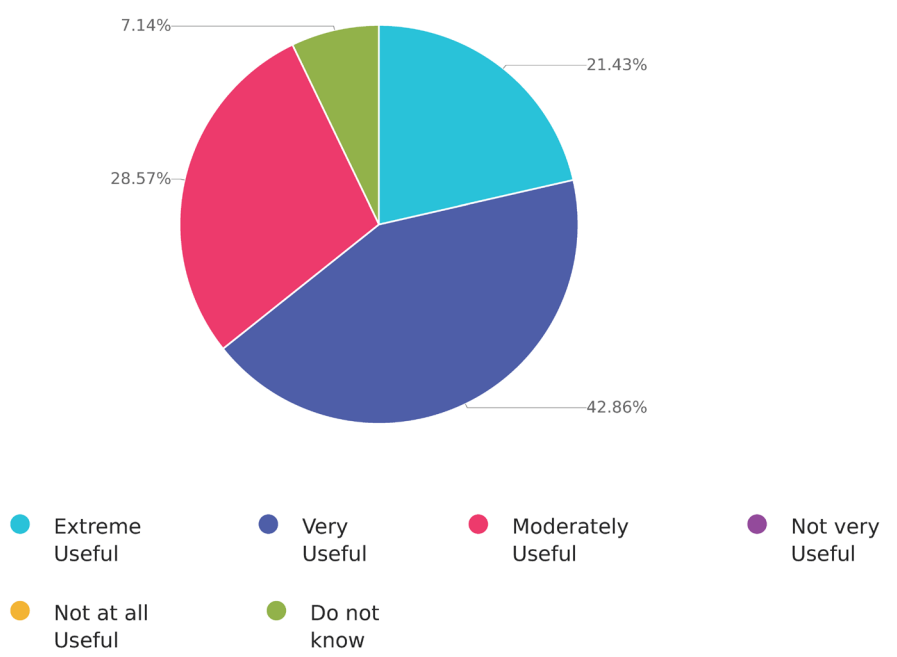
Answered: 14 Skipped: 0



Choices	Response percent	Response count
Extreme Useful	14.29%	2
Very Useful	64.29%	9
Moderately Useful	21.43%	3
Not very Useful	0.00%	0
Not at all Useful	0.00%	0
Do not know	0.00%	0

How useful was the Urban Calculator in testing different design alternatives?

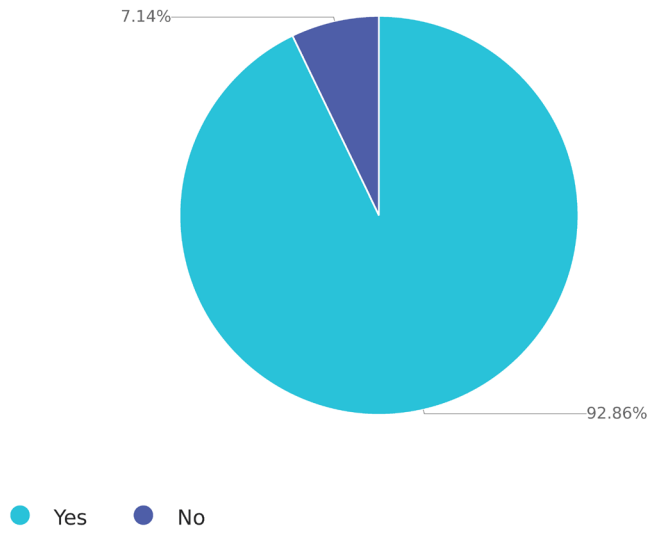
Answered: 14 Skipped: 0



Choices	Response percent	Response count
Extreme Useful	21.43%	3
Very Useful	42.86%	6
Moderately Useful	28.57%	4
Not very Useful	0.00%	0
Not at all Useful	0.00%	0
Do not know	7.14%	1

Would you use the Urban Calculator in other projects?

Answered: 14 Skipped: 0



Choices	Response percent	Response count
Yes	92.86%	13
No	7.14%	1

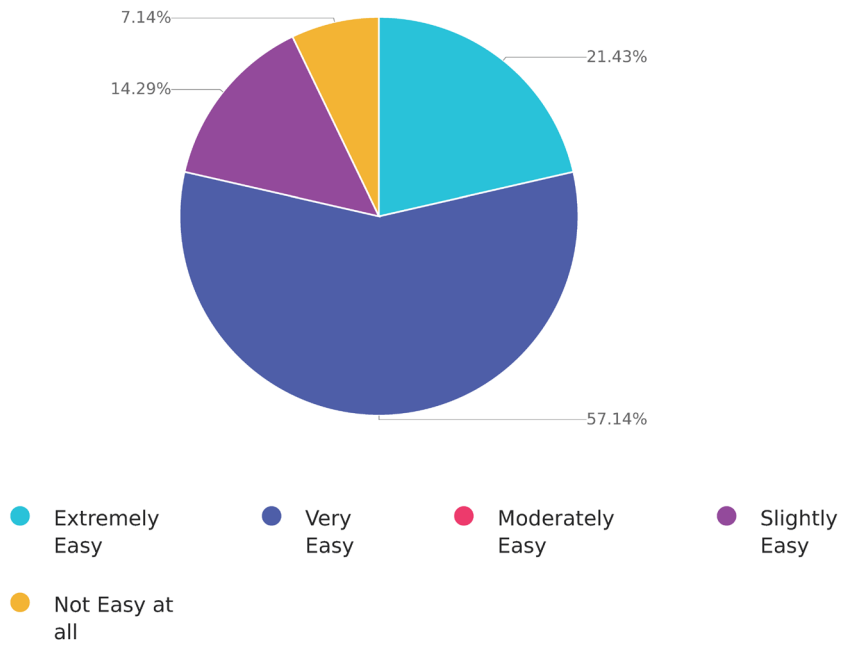
Can you please tell us for what purpose you would use it?

Answered: 10 Skipped: 4

1. To test the effect of different choices of connections with roads, to see how close it is to public transport etc, to see differences in centrality between the network for walkers and drivers.
2. Space syntax analysis
3. The program would benefit from having a pan setting so that you don’t have to zoom out and then zoom in on another part of the screen in order to move the frame.
4. För att se om ett befintligt område är centralt eller segregerat sett till vägnätet
5. Som underlag för att bestämma placering av olika typer av verksamheter, samt planera stadsnätet efter olika typer av funktion
6. To find out where to put important social functions in an area
7. In the sketch-process, trying to understand a site
8. För att se och förstå förändringar i större skala
9. To determine the configurational properties of a site and to test design alternatives against these properties
10. Please make it work for Mac-computers.

Can you please tell us, how easy was it to install the tool?

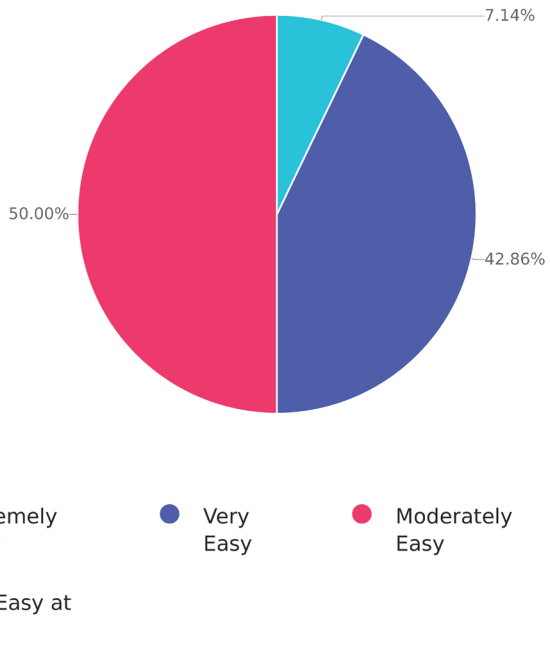
Answered: 14 Skipped: 0



Choices	Response percent	Response count
Extremely Easy	21.43%	3
Very Easy	57.14%	8
Moderately Easy	0.00%	0
Slightly Easy	14.29%	2
Not Easy at all	7.14%	1

How easy was it to use the tool (editing, analysis, output PDF)?

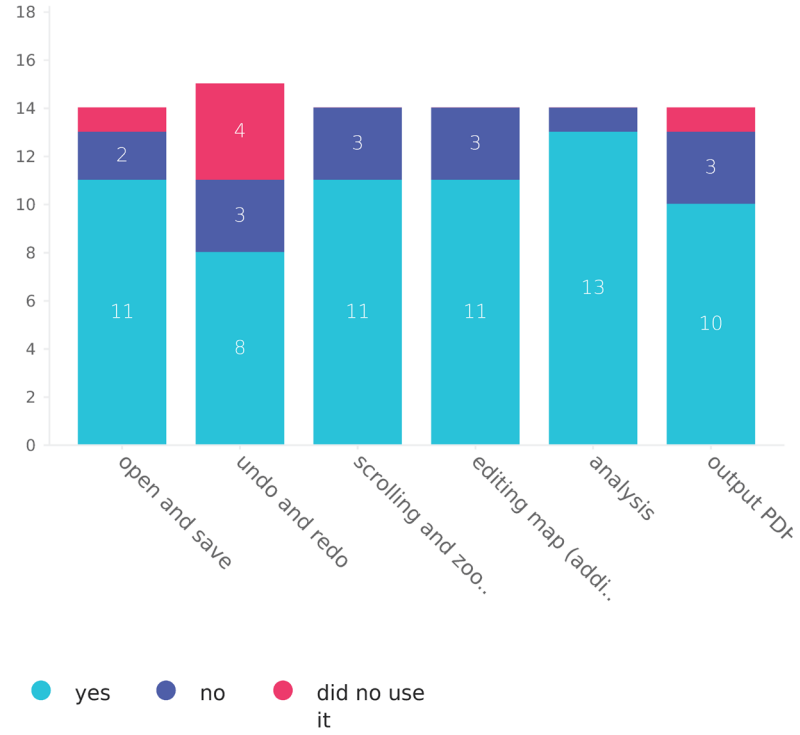
Answered: 14 Skipped: 0



Choices	Response percent	Response count
Extremely Easy	7.14%	1
Very Easy	42.86%	6
Moderately Easy	50.00%	7
Slightly Easy	0.00%	0
Not Easy at all	0.00%	0

Did the following features of the tool work properly?

Answered: 14 Skipped: 0



Row	yes	no	did no use it	Response count
open and save	78.57% (11)	14.29% (2)	7.14% (1)	14
undo and redo	57.14% (8)	21.43% (3)	28.57% (4)	14
scrolling and zooming	78.57% (11)	21.43% (3)	0.00% (0)	14
editing map (adding and removing lines or unlinks)	78.57% (11)	21.43% (3)	0.00% (0)	14
analysis	92.86% (13)	7.14% (1)	0.00% (0)	14
output PDF	71.43% (10)	21.43% (3)	7.14% (1)	14

What other features not listed above did not work properly?

Answered: 7 Skipped: 7

1. The program crashed if forgetting what map one was on and trying to do things one couldnt there. It chrashed two or three times for us. It would not scoll and it was a bit difficult to zoom in and out so that you got the right window. It would be useful to be able to focus the window in a specific place on the map, so the maps you compare are exactly the same.
2. There is no pan tool (the hand)!!! Some saved ucmap files couldn't be opened. Roundabouts work as individual streets.
3. Allt fungerar som det är tänkt, så länge programmet inte hänger sig, vilket händer ofta vid ex 5km analys Otydligt vad funktioner som ex schools faktiskt inkluderar (skola vs förskola etc)
4. The programme crashed one time and our work was lost.
5. When analyzing a large area the application often shut down.
6. test
7. xx

Q11

What other features should be included to make the software more useful?

Answered: 6 Skipped: 8

1. More datasets to compare. Public transport as a kind of portal in the network, connecting it to other places in the city, with some resistance acounting for time. It would be nice to be able to show the results in different ways, it could be difficult to see small changes when the lineweight was the only thing that tells you the result, perhaps colours like in the other maps too for example.
2. A pan tool
3. Höjdkurvor för att kunna avgöra topografiska hinder för ex vägdragning hade varit väldigt användbart
4. To be able to oversee roundabouts in the analysis, they concist of many little lines and skew the results somewhat
5. test
6. xx
